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UNION OF SOUTH AFRICA

DEPARTMENT OF COMMERCE AND INDUSTRIES

DIVISION OF FISHERIES
INVESTIGATIONAL REPORT No. 31

THE SOUTH AFRICAN PILCHARD
(Sardinops ocellata)
AND MAASBANKER
(Trachurus trachurus)

THE PREDATION OF SEA-BIRDS IN THE COMMERCIAL FISHERY

BY

D. H. DAVIES, M.Sc., Ph.D.
(Formerly Senior Professional Officer, Division of Fisheries, now *Institute of Marine Resources*, University of California.)

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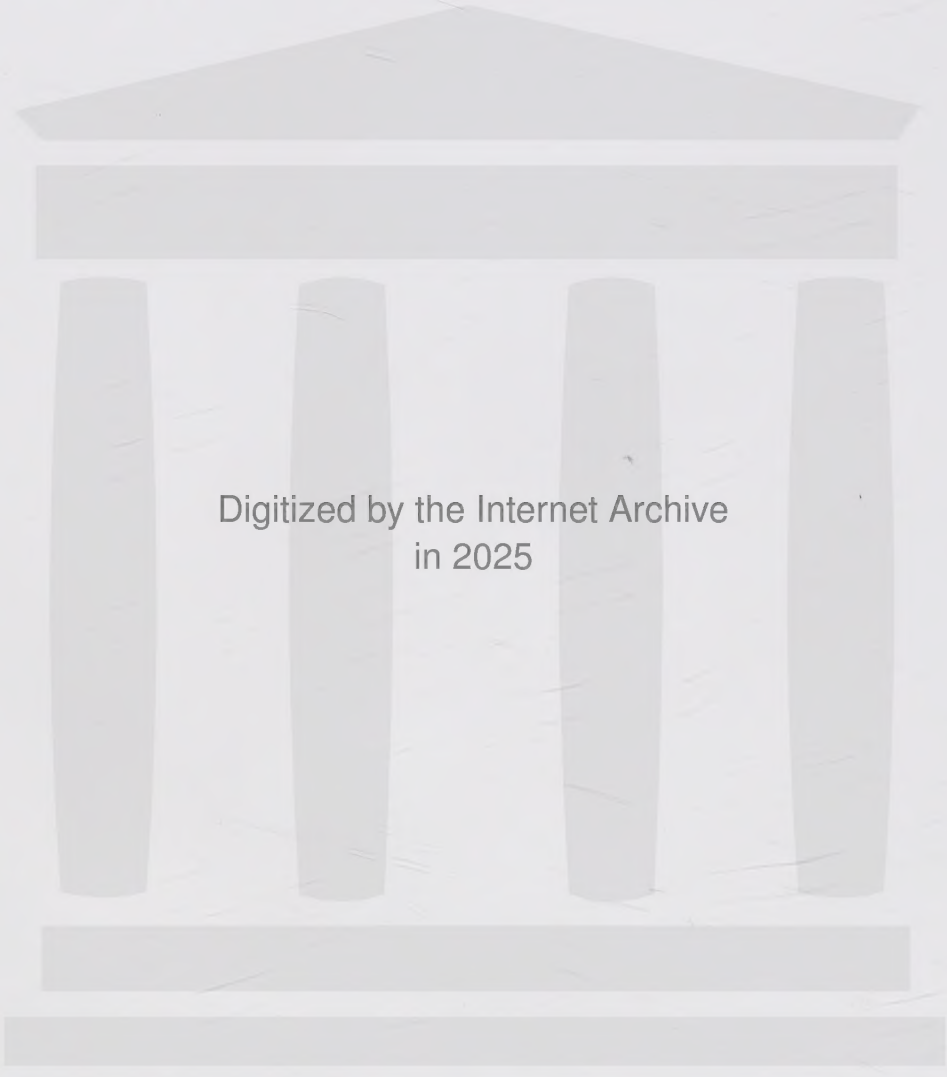
Union of South Africa



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1. Abstract.

In this report* the data obtained in an investigation into the feeding of sea-birds off the West coast of the Union of South Africa are reviewed. *The investigation was begun in* 1952 *and concerned the three main species of fish-eating sea-birds found in the pilchard/maasbanker commercial fishing area.* These three species, the Gannet, the Cape Cormorant and the Penguin are present in the area in large numbers during the greater part of the year, and as a result of their activities as fish-eaters are the main species concerned in the production of guano.

The investigations have shown that the gannet, the Cape cormorant and the penguin prey extensively on commercially-valuable fish, mainly pilchards and maasbankers. In addition, the investigations provided a good idea of the quantities consumed, but until recently no reliable estimate of the numbers of these birds was available.

In November, 1956, however, the Director of the Trigonometrical Survey of the Union of South Africa at the request of the Division of Fisheries, carried out an aerial photographic survey of the bird islands off the West coast of the Union. From this survey counts were made and accurate overall census figures are now available for the first time.

The availability of these total census figures has thus made it possible for a reasonably reliable assessment of the predation of sea-birds on commercial fish stocks to be made for the West coast of South Africa.

2. Introduction.

This report is one of a series dealing with the biology of the South African Pilchard, (*Sardinops ocellata*) and Maasbanker, (*Trachurus trachurus*) and is the third and final paper by the author on the sea-bird predators of these two species in the commercial fishing area. The first report (Davies, 1955) was based on a number of preliminary stomach-content investigations, which were begun in April, 1952, together with continuous investigations during the period March, 1953, to February, 1954. The second report (Davies, 1956) was based on data collected during the period March, 1954, to February, 1955. The present report is based on all this information together with further data collected during the period March, 1955, to May, 1957.

The object of this report is not only to provide a reasonably reliable assessment of the predation of sea-birds on the pilchard and maasbanker, but also to draw attention to the problem of the predation of commercially-valuable guano-producing sea-birds on commercially-valuable fish stocks.

This has now been made possible in consequence of the satisfactory completion of an aerial photographic survey of the main bird islands off the West coast of the Union carried out by the Trigonometrical Survey with the co-operation of a Dakota aircraft and crew of the South African Air Force. The survey was carried out in November, 1956, as, during this month, gannets, Cape cormorants and penguins congregate on the islands in maximum numbers for breeding purposes.

Before the survey was undertaken a series of experimental photographs was taken in order to ascertain at what height the aircraft could fly without disturbing the birds—thereby causing them to leave the islands—and at the same time produce photographs which, when suitably enlarged, would permit the actual counting of the individual birds. The most suitable altitude was found to be 750 feet above the ground using a Wild R.C. 5a camera of focal length six inches.

The arduous task of counting the birds from the large numbers of enlargements made was carried out by Mr. R. W. Rand, M.Sc., of the Division of Fisheries, who is preparing a detailed account of the census, including the method of counting, etc., which will be published as an investigational report.

In this report, no attempt has been made to deal with the details of the methods used in the feeding investigations, the various procedures adopted or the initial assessments and presentation of results, as this would have involved unnecessary repetition. This information is given in full detail in the first and second reports on sea-bird predation (Davies, 1955 and 1956). It may be necessary therefore to consult the two previous reports in order to obtain the details and the full background of this predation study.

The entire investigation was carried out in the inshore waters of the main area of commercial fishing for pilchards and maasbankers between Saldanha Bay and Lambert's Bay off the West coast of the Union of South Africa (see Fig. 1). In recent years and mainly during periods of scarcity of fish, commercial catches of pilchards have been made in the vicinity of Dassen Island,

* Manuscript received 28 June, 1957.

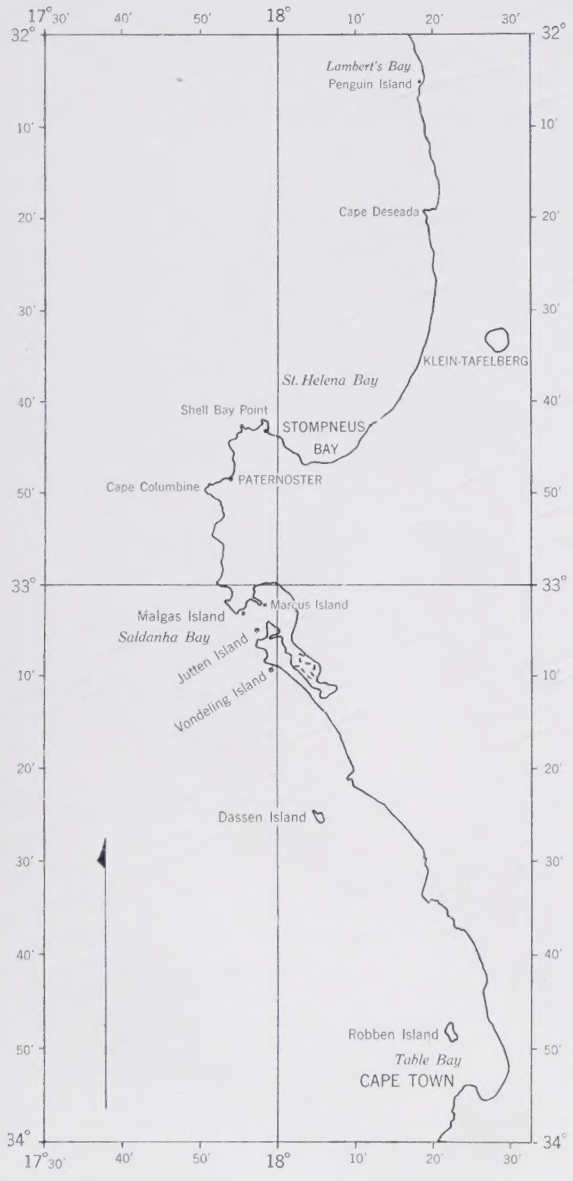

FIG. 1 THE WEST COAST OF SOUTH AFRICA

Trigsurvey, 1957. Government Printer, 1958.

Robben Island and as far south as False Bay (not shown in figure). Investigations into the feeding of sea-birds in the area to the south between Saldanha Bay and False Bay have been carried out by Rand and will be published at a later date.

Three species of sea-bird are important predators of pelagic fish off the West coast of South Africa. They are the Cape Gannet, the Cape Cormorant and the Cape Penguin. All three inhabit rookeries situated on the islands off the West coast (see Fig. 1). These rookeries are ideally situated in an area where large shoals of pelagic fish abound during the greater part of the year.

3. The Cape Gannet (Morus capensis)

Feeding studies in relation to the Cape Gannet off the West coast of the Union were carried out from 1952 onwards over a period of nearly four and a half years and involved the examination of the stomachs of 479 birds.

Based on these investigations the food of the gannet off the West coast of the Union was found to consist of fish of the following species (see Fig. 2):—

(*a*) Pilchard (*Sardinops ocellata*), 54 per cent.
(*b*) Maasbanker (*Trachurus trachurus*), 16 per cent.
(*c*) Anchovy (*Engraulis japonicus*), 15 per cent.
(*d*) Harder or Mullet, (*Liza ramada*), 3 per cent.
(*e*) Mackerel (*Scomber japonicus*), 1 per cent.
(*f*) Fish remains, unrecognisable, 11 per cent.

Of these, the pilchard and the maasbanker are the most important species since they form the basis of the pelagic fishery off the West coast. Harders and mackerel are of lesser commercial importance and the anchovy has not yet been used commercially in spite of the fact that it is present in large numbers at certain times of the year and is as good in quality when processed as anchovies from other countries.

Gannets are estimated to feed at the rate of 4 lb. of fish a day (Davies, 1956) and to feed successfully during two thirds of the year, i.e. 244 days. One third of the year was discounted as feeding time due to bad weather, the breeding activities of the birds and the non-availability of fish. On this basis, each bird consumes 976 lb. of fish per year, of which 527 lb. consist of pilchards (of which 395 lb. are of commercial size and 132 lb. below commercial size) and 156 lb. of maasbankers (of which 117 lb. are of commercial size and 39 lb. below commercial size).

Gannets are concentrated in two main rookeries off the West coast of South Africa, viz. Malgas Island in Saldanha Bay and Penguin Island off Lambert's Bay (see Fig. 1). The actual counts of gannets obtained for these islands in the November aerial survey are shown in Table 1 and amount to a total of 30,500 birds. This figure represents single adult birds at nests and, as the weather was

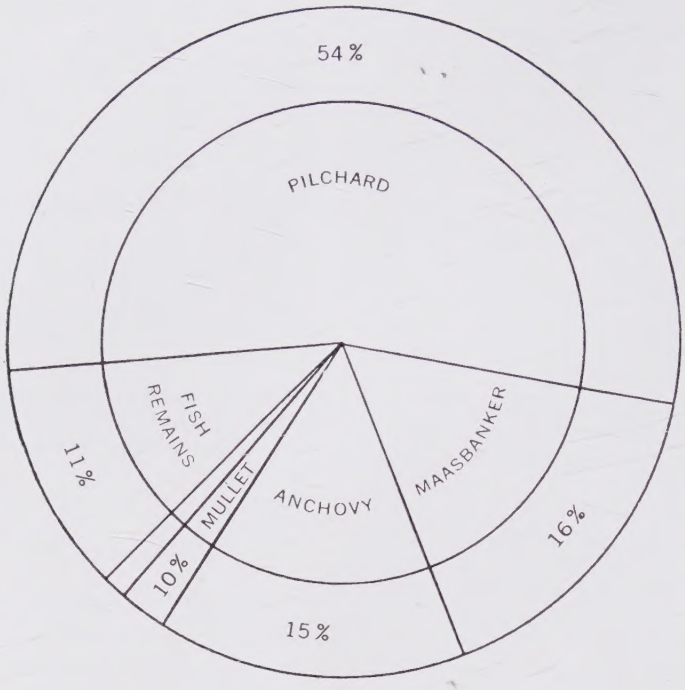

FIG. 2.

THE FOOD OF THE CAPE GANNET
(Morus capensis)

fine when the photography was carried out it may be taken that the other member of each pair was away from the island engaged in feeding activities. In order to obtain the total number of *adult* gannets breeding on the island the figure of 30,500 may therefore be doubled, giving a figure of 61,000 birds. Each pair of adult gannets produces a single young in a season, but as the rate of survival of chicks is not known, and as the young birds migrate to other areas shortly after leaving the islands and remain absent from the West coast area from one to two years until they have become fully adult, it is not considered reasonable to include them at all. Those that eventually return to the West coast islands probably make up for losses to the normal population due to natural mortality, etc.

The total adult gannet population of the West coast of the Union of South Africa may therefore be taken as being 61,000 *birds.* This figure is rather widely different from previous estimates used. Broekhuysen and Rudebeck (1951) made an estimate of 131,000 gannets for Malgas Island alone; this estimate included an allowance of one juvenile for each pair of adults and was made on the basis of a ground survey. Rand (1955) estimated that the population of Malgas Island was 40,600 gannets. This estimate was based on aerial photographs together with a ground survey carried out in January, 1955, and included an allowance of one juvenile per pair of adults with a deduction on the basis of a theoretical 10 per cent mortality of young birds.

No great changes in the gannet population of Malgas Island have been observed and it appears that the first estimate made by Broekhuysen and Rudebeck was excessively high, while Rand's later estimate was probably an accurate reflection of the number of birds on the island during the *latter* part of the breeding season when many birds had

already left. Rands' previous estimate of the gannet population of Penguin Island (Lambert's Bay) of 25,000 birds was high in relation to his latest count of 6,200 birds (actual count), giving 18,600 birds including both parents and young birds.

With a total adult gannet population of 61,000 *feeding at the rate of* 976 *lb. of fish per bird per year, a total of* 29,768 *tons—in round figures* 29,800 *tons of fish is eaten off the West coast of the Union of South Africa per year.* Of these 29,800 tons of fish *approximately* 16,000 *tons consist of pilchards and* 4,800 *tons of maasbankers.* Of the pilchards eaten, approximately 12,500 tons consist of fish of a size normally caught in the commercial catches. Of the maasbankers eaten, approximately 3,600 tons consist of fish of a size normally caught in the commercial catches.

4. The Cape Cormorant (Phalacracorax capensis).

The study of the feeding of the Cape Cormorant off the West coast of South Africa began in 1952 and was continued for a period of over four years. During this feeding study a total of 293 cormorant stomachs was examined.

On the basis of the data obtained from these investigations the food of the Cape cormorant off the West coast of the Union of South Africa was found to consist of the following (see Fig. 3):—

(*a*) Pilchard (*Sardinops ocellata*), 51 per cent.

(*b*) Anchovy (*Engraulis japonicus*), 16 per cent.

(*c*) Rock-fish or *Klipvis* (*Clinus* spp.), 9 per cent.

(*d*) Maasbanker (*Trachurus trachurus*), 8 per cent.

(*e*) Hottentot (*Pachymetopon blochii*), <1 per cent.

(*f*) Fish remains, unrecognisable, 13 per cent.

(*g*) Shrimp (*Palaemon pacificus*), 2 per cent.

(*h*) Rock Lobster (*Jasus lalandii*), 1 per cent.

It is evident therefore that the pilchard is by far the most important food organism in the diet of the Cape cormorant off the West coast. The only other commercially-important species eaten are the maasbanker and the rock lobster, the latter being eaten in very small numbers.

Cape cormorants are estimated to feed at the rate of 1 lb. 4 ozs. a day (Davies, 1956) and to feed successfully during two thirds, i.e. 244 days, of the year. One third of the year was discounted as feeding time due to bad weather, the breeding activities of the birds and the non-availability of food. On this basis, each bird consumes an amount of 300 lb. of fish per year (5 lb. having being deducted as being crustaceans). Of the 300 lb., 153 lb. consist of pilchards (of which 104 lb. are of commercial size and 49 lb. below commercial size) and 24 lb. of maasbankers (of which only 6 lb. are of commercial size and 18 lb. below commercial size).

The Cape cormorants of the West coast of the Union breed mainly on Penguin Island off Lambert's Bay, Jutten Island in Saldanha Bay and on Vondeling Island (see Fig. 1). The actual counts of cormorants obtained for these islands in the November aerial survey are shown in Table I and amount to a total of 60,150 birds. This figure represents single adult birds at nests and, as the weather was fine when the photography was carried out it may be taken that the other member of each pair was away from the island engaged in feeding activities. In order to obtain the total number of adult cormorants breeding on the islands the figure of 60,150 may therefore be doubled, giving a figure of 120,300 birds. Each pair of adult Cape cormorants produces two to three eggs but it is rare for more than two chicks to leave the nest and no data concerning the rate of survival of these chicks are available. It was therefore decided not to include the young Cape cormorants in the census.

The total adult Cape cormorant population for the West coast of the Union of South Africa may therefore be taken as being 120,000 *birds* (*in round figures*). The previous figures used for Cape cormorants recorded in the commercial fishing area off the West coast ranged from 20,000 (average) to 41,800 birds (maximum count). These figures were based on regular counts made in the St. Helena Bay area (Davies, 1956), and, bearing in mind the strong migratory habits of the Cape cormorant, they are considered to represent a fairly accurate reflection of the numbers of birds operating in the St. Helena Bay area. Maximum counts of feeding cormorants in this area were obtained during the winter months.

It is known that the Cape cormorant undertakes extensive migratory flights probably in search of food. According to Rand (1950, 1952) both young birds and adults fly northwards in large numbers to the Walvis Bay area off the coast of South West Africa. In general, this cormorant is said to move along the coast between a southerly

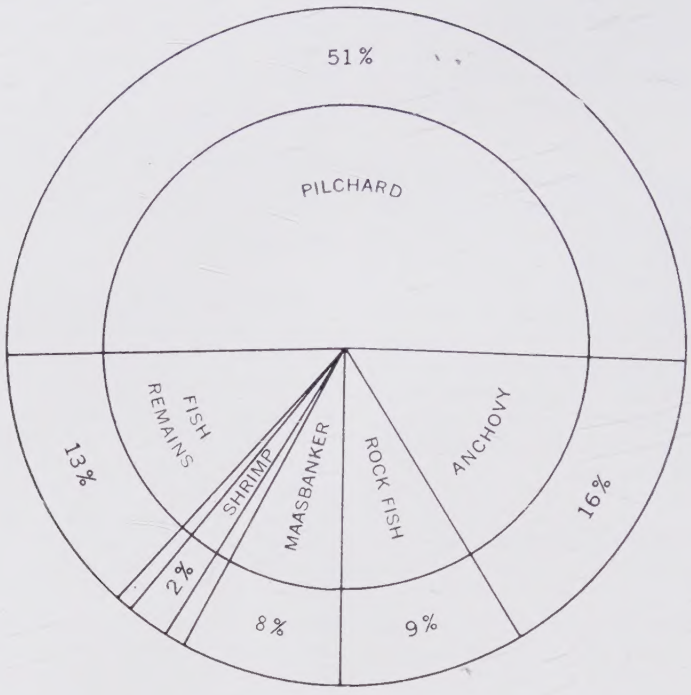

FIG. 3.

THE FOOD OF THE CAPE CORMORANT
(Phalacracorax capensis)

summer breeding range and a notherly non-breeding range in winter. Unfortunately, however, no detailed quantitative data on the movements of this species are available. It is understandable that Cape cormorants migrate away from the West coast area during the summer months due to the absence of suitable food. Pilchard, anchovy and maasbanker shoals are generally absent from this area in summer and it is possible that the large scale desertion of eggs and young reported for this species at times may be due to the fact that food supplies are at times quite inadequate. During most summer seasons, however, the areas of Table Bay and False Bay in the south abound with shoals of young pilchard, anchovy, maasbanker and mackerel and it is likely that the breeding Cape cormorants obtain most of their food from these areas.

In spite of the Cape cormorant's extensive migrations, which are reported to be to the north in winter (Rand, 1952), the largest counts for this species were obtained in the St. Helena Bay area in this season and the smallest counts in the summer (Davies, 1956). It is considered that the decrease in numbers obtained in the spring and summer months are due mainly to the fact that approximately half the birds are confined to the islands for breeding purposes, and that in spite of their extensive migrations the West coast of the Union supports a population of Cape cormorants, which although fluid, remains at a fairly constant level.

As there are no data available concerning the rate of survival of young Cape cormorants and because they probably migrate elsewhere on leaving the nest, it was considered advisable to discount them entirely in the population estimate.

As it is apparent that some part of the population of Cape cormorants off the West coast of the Union is absent at various times of the year, it was decided to make allowance for this by deducting one third (40,000 birds) of the total number of birds obtained in the November census, viz. 120,000 birds, thus giving a permanent population figure of these cormorants of 80,000 birds.

With a total Cape cormorant population of 80,000 *birds feeding at the rate of* 300 *lb. of fish per bird per year, a total of* 12,000 *tons of fish is eaten off the West coast of the Union of South Africa. per year. Of these* 12,000 *tons of fish, approximately* 6,000 *tons consist of pilchards and nearly* 1,000 *tons of maasbankers.* Of the pilchards eaten, approximately 4,000 tons consist of fish of a size normally caught in the commercial catches, of the maasbankers eaten, approximately 250 tons only consist of fish normally caught in the commercial catches.

5. The Cape Penguin (Spheniscus demersus).

Investigations into the feeding of the Cape (or Jackass) penguin were started in 1953 and continued for a period of nearly three and a half years. The stomach contents of 307 penguins were examined in the course of these investigations.

The food of the penguin off the West coast of the Union of South Africa was found to consist of the following (see Fig. 4):—

(*a*) Pilchard (*Sardinops ocellata*), 45 per cent.
(*b*) Anchovy (*Engraulis japonicus*), 36 per cent.
(*c*) Maasbanker (*Trachurus trachurus*), 2 per cent.
(*d*) Mackerel (*Scomber japonicus*), 1< per cent.
(*e*) Fish remains, unrecognisable, 14 per cent.
(*f*) Squid (*Loligo reynaudi*), 2 per cent.
(*g*) Crab larvae (*Megalopa* stages), 1 per cent.

It is evident from this list that the pilchard is by far the most important organism in the diet of the penguin off the West coast of the Union. The anchovy is also of considerable importance and these two species comprise over 80 per cent of the food of the penguin in this area.

Penguins are estimated to feed at the rate of 3 lb. 8 ozs. of food a day (Davies, 1956), but, unlike the gannet and the Cape cormorant, breed twice a year mainly in spring and late autumn. Two chicks are usually reared in each breeding cycle over a period of approximately three months. Penguins are able to build up large reserves of fat during periods of intensive feeding and then remain without food for considerable periods ashore during the breeding seasons. Because of their ability to build up food reserves and because they spend longer periods ashore, it was considered that an allowance should be made in the estimate of total successful feeding time per year. A further amount of 30 days or one month was therefore deducted from the previous estimate of 244 days giving a period of 214 days successful feeding per year, the remainder of the year (approximately 41 per cent) having been discounted as feeding time due to bad weather, the non-availability of food and the breeding activities of the birds. On this basis, each bird consumes 749 lb. of food per year of which 727 lb. consist of fish. Of this amount, 327 lb. consist of pilchards (of which 140 lb. are of commercial size and 187 lb. below commercial size) and 15 lb. of maasbankers all of which are below commercial size.

Penguins are widely distributed off the West coast of the Union and are found on Dassen Island, Vondeling Island, Jutten Island, Marcus Island, Malgas Island and Penguin Island off Lambert's Bay (see Fig. 1). By far the largest concentrations of penguins are found on Dassen Island and considerable numbers are found on Jutten and Marcus Islands in Saldanha Bay. The actual counts of penguins obtained for all these islands in the November aerial survey are shown in Table I and amount to a total of 97,285 birds. This figure represents mainly adult birds at nests. It is likely, according to the observed habits of the penguins, that less than half the total number of adult birds were absent from the island engaged in feeding activities and consequently an addition of one third of the total count of penguins obtained, has been added to the total count giving an estimated total adult penguin population of 129,713 birds, or in round figures 130,000 penguins. Although penguins produce two broods, each consisting of at least two chicks per year, nothing is known of the rate of survival of chicks and young birds. They have therefore not been included in the total population estimate of penguins.

The total adult penguin population for the West coast of the Union of South Africa may therefore be taken as being 130,000 *birds.* No census figures for penguins were available for previous estimates and this figure is the first which has been based on an actual count of the birds off the West coast.

With a total adult penguin population of 130,000 *feeding at the rate of* 727 *lb. of fish per bird per year, a total of* 47,255 *tons or in round figures* 47,300 *tons of fish is eaten off the West coast of the Union per year. Of this amount of* 47,300 *tons of fish, approximately* 21,300 *tons consist of*

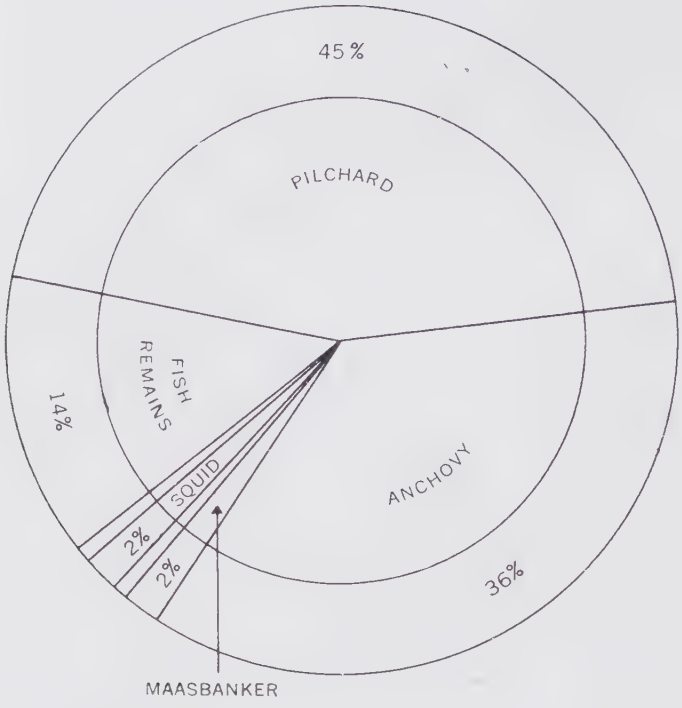

FIG. 4.

THE FOOD OF THE CAPE PENGUIN
(Spheniscus demersus)

pilchards and 980 *tons of maasbankers.* Of the pilchards eaten, approximately 9,200 tons consist of fish of a size normally caught in the commercial catches. All the maasbankers eaten are below the size normally caught in the commercial catches.

6. Summary of Findings.

During the course of investigations* into the feeding of the sea-birds off the West coast of the Union of South Africa, carried out over a period of over four years with the object of assessing their depredations on the commercially-valuable fish stocks of the area, the following findings were made:—

1. Of eleven species of sea-birds originally investigated, only three are considered to be important predators of commercially-valuable fish, particularly the pilchard.

2. The three important sea-bird predators of commercially-valuable fish off the West coast of the Union are the Cape Gannet or *Malgas*, the Cape Cormorant or *Trek Duiker* and the Cape or Jackass Penguin.

3. The food of the gannet (see Fig. 2) off the West coast of the Union consists entirely of fish of the following species:—

(*a*) Pilchard (*Sardinops ocellata*), 54 per cent.

(*b*) Maasbanker (*Trachurus trachurus*), 16 per cent.

* For further details concerning the background of these investigations, see Davies (1955 and 1956).

(*c*) Anchovy (*Engraulis japonicus*), 15 per cent.

(*d*) Mullet or Harder (*Liza ramada*), 3 per cent.

(*e*) Mackerel (*Scomber japonicus*), 1 per cent.

(*f*) The remaining 11 per cent was made up of the unrecognisable remains of fish.

4. Based on counts made from an aerial photographic survey, the total adult gannet population of the West coast of the Union is estimated to be 61,000 birds.

5. The gannet population of the West coast of the Union consumes approximately 30,000 tons of fish a year, of which 16,000 tons consist of pilchards and 5,000 tons of maasbankers.

6. The food of the Cape cormorant (see Fig. 3) off the West coast of the Union consists of the following:—

(*a*) Pilchard (*Sardinops ocellata*), 51 per cent.

(*b*) Anchovy (*Engraulis japonicus*), 16 per cent.

(*c*) Rock-fish or *Klipvis* (*Clinus* spp.), 9 per cent.

(*d*) Maasbanker (*Trachurus trachurus*), 8 per cent.

(*e*) Hottentot (*Pachymetopon blochii*), 1 per cent.

(*f*) Shrimp (*Palaemon pacificus*), 2 per cent.

(*g*) Rock Lobster (*Jasus lalandii*), 1 per cent.

(*h*) The remaining 13 per cent was made up of the unrecognisable remains of fish.

7. Based on counts made from an aerial photographic survey, the maximum total adult Cape cormorant population of the West coast of the Union is estimated to be 120,000 birds. Due to the fact that this species is a constant migrant, particularly between the pilchard fisheries of South West Africa and the Union, it is considered that the average number of Cape cormorants feeding off the West coast of the Union throughout the year is approximately 80,000 birds.

8. The Cape cormorant population of the West coast of the Union consumes 12,000 tons of fish a year, of which 6,000 tons consist of pilchards and nearly 1,000 tons of maasbankers.

9. The food of the Cape penguin (see Fig 4) off the West coast of the Union consists of the following:—

(*a*) Pilchard (*Sardinops ocellata*), 45 per cent.

(*b*) Anchovy (*Engraulis japonicus*), 36 per cent.

(*c*) Maasbanker (*Trachurus trachurus*), 2 per cent.

(*d*) Mackerel (*Scomber japonicus*), <1 per cent.

(*e*) Squid (*Loligo reynaudi*), 2 per cent.

(*f*) Crab larvae (*Megalopa* stages), 1 per cent.

(*g*) The remaining 14 per cent was made up of the unrecognisable remains of fish.

10. Based on counts made from an aerial photographic survey, the total adult penguin population of the West coast of the Union is estimated to be 130,000 birds.

11. The penguin population of the West coast of the Union consumes over 47,000 tons of fish a year, of which more than 21,000 tons consist of pilchards and nearly 1,000 tons of maasbankers.

12. The gannets, Cape cormorants and penguins of the West coast of the Union consume over 43,000 tons of pilchards and nearly 7,000 tons of maasbankers a year.

7. General Discussion.

The pilchards and maasbankers of the West coast of the Union have many predators including fish such as snoek (*Thyrsites atun*) and stockfish (*Merluccius capensis*), seals (*Arctocephalus pusillus*), sea-birds and man. Snoek shoals prey heavily on pilchards and to some extent on small maasbankers but are only present off the West coast of the Union during two to three months of the year. Stockfish prey on pilchards and maasbankers only when the latter two species migrate to off-shore waters. Seals may consume considerable quantities of both pilchards and maasbankers off the West coast of the Union but sea-birds and man probably cause the greatest mortality of these fish in Union waters.

In June, 1954, the following motion was made and unanimously carried in the Senate of the Union of South Africa:—

> " That this house requests the Government to investigate the effect on sea-food sources of various fish-eating birds and animals and to consider whether steps should be taken to destroy such birds and animals."

As a result of these investigations into the feeding of the sea-birds off the West coast of the Union, started in 1952 and continued through to

1957, scientific knowledge concerning the depredations of sea-birds on commercially-valuable fish stocks has made considerable advances, and a general assessment on the effect of fish-eating birds on sea-food resources is now possible.

An investigation into the feeding of seals has also been completed and an assessment of their depredations on commercially-valuable fish will appear in the form of a paper by R. W. Rand of the Division of Fisheries.

In previous reports on the predation of sea-birds on the commercially-valuable pelagic fish of the West coast, it was felt that the main weakness in the assessments made lay in the absence of any form of reliable counts of the sea-birds concerned (Davies, 1955 and 1956). Steps were therefore taken to obtain overall census figures for the islands off the West coast of the Union of South Africa by means of an aerial photographic survey. It was arranged that this survey should take place during the breeding season of the birds when the greatest concentrations were to be found on the islands. The first survey was attempted in November, 1955, but was unsuccessful due to bad visibility and adverse weather conditions. The second survey took place in November, 1956, and was most successful and resulted in the production of a series of photographs of the islands off the West coast of the Union being taken as near to simultaneously as possible, i.e. on the same day. From these photographs accurate counts have been made.

The possession of census figures for the birds of the West coast islands of South Africa, together with the data obtained from feeding investigations carried out in the area of commercial fishing during a period of over four years, have made it possible to make a general assessment of the predation of the three important species of sea-birds on commercially-important fish.

The feeding study has shown that in this area the main organisms comprising the diet of the gannet, the Cape cormorant and the penguin are the pilchard, the anchovy and the maasbanker. Other organisms eaten are of minor significance. There is no doubt, however, that organisms other than those listed in this report will be found among the stomach contents of these birds in other areas, but the mainstay of the sea-bird population of the West coast consists of pilchards, anchovies and maasbankers.

As this is a consideration of the depredations of sea-birds on *commercially*-valuable fish stocks, the anchovy has been omitted from the table below in which the total annual consumption of gannets, Cape cormorants and penguins is presented. There is no doubt, however, that the anchovy will eventually be utilised commercially with the result that the depredations by birds on this species will have to be taken into consideration.

ANNUAL CONSUMPTION OF COMMERCIALLY-IMPORTANT FISH BY THE SEA-BIRDS OF THE WEST COAST OF THE UNION OF SOUTH AFRICA.

SEA-BIRD.	PILCHARD.		MAASBANKER.	
	All Sizes.	Commercial Sizes Only.	All Sizes.	Commercial Sizes Only.
	Tons.	Tons.	Tons.	Tons.
Gannet	16,000	12,500	4,800	3,600
Cape Cormorant	6,000	4,000	1,000	250
Penguin	21,300	9,200	980	—
TOTAL	43,300	25,700	6,780	3,850

Total Tonnage of Pilchards and Maasbankers = **50,000** *tons* (all sizes, in round figures).

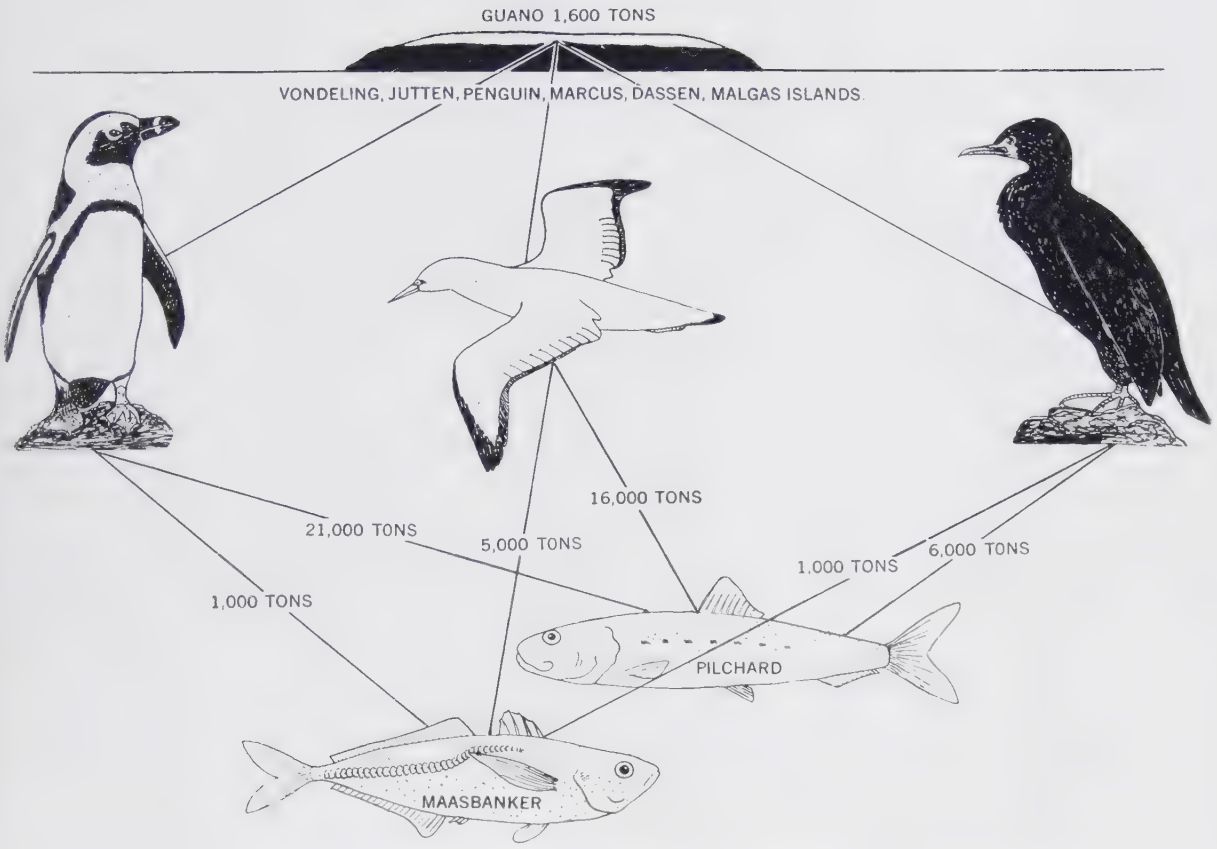

FIG. 5. FISH CONSUMPTION AND GUANO PRODUCTION OFF THE WEST COAST OF THE UNION OF SOUTH AFRICA.

For purposes of comparison, a table showing the commercial catch data of pilchards and maasbankers is included.

TOTAL ANNUAL COMMERCIAL CATCHES OF PILCHARDS AND MAASBANKERS OFF THE WEST COAST OF THE UNION OF SOUTH AFRICA, 1951–56.

Year.	Pilchard.	Maasbanker.
	Tons.	Tons.
1951	109,610	111,292
1952	187,424	113,136
1953	150,987	93,140
1954	97,336	130,228
1955	134,424	86,885
1956	84,175	50,233
1951–56 mean	127,326	97,486

From the foregoing two tables it is evident that the total consumption of pilchards and maasbankers by sea-birds off the West coast (50,000 tons) amounts to 22 per cent of the average commercial catch of both species for the last six years. If pilchards and maasbankers of commercial size only are considered then the quantity consumed by the birds amounts to only 13 per cent of the average total catch. As gannets, Cape cormorants and penguins feed mainly on late juvenile pilchards and maasbankers at a stage when natural mortality has become relatively low, it is considered more reasonable to use the figures for all sizes of fish, i.e. 50,000 tons, in assessing the possible effects of the feeding of the birds on the commercial fishery. It should also be borne in mind that the latter figure is minimal rather than maximal, since the entire treatment of the data including, for example, generous allowances for non-feeding periods, estimates of numbers of birds, etc., has been on an extremely conservative basis.

It is important to note that the figure of 43,300 tons of pilchards consumed annually by the birds amounted to nearly half the total catch of pilchards for the year 1956. This shows that the whole problem of the consumption of pilchards and maasbankers off the West coast varies in relation to the availability of the fish for commercial catching. During a good year when fish are abundant it is unlikely that the consumption of fish by the birds has any appreciable effect on commercial fishing. *When the fish are scarce, however, there is no doubt that the feeding activities of the birds have a marked effect on the fishery.*

The gannets, the Cape cormorants and the penguins are given complete protection by law due to the fact that they produce guano which is highly prized as a fertilizer for the market gardener. The penguins, in addition, produce eggs which are a great delicacy and are sold in large quantities usually once a year.

The production figures for guano and penguin eggs during the last four years were as follows:—

Year.	Guano.	Penguin eggs.
	Tons.	
1953	5,600	148,000
1954	5,734	148,248
1955	5,316	No collection.
1956	4,583	123,432

The islands off the West coast of the Union of South Africa (see Fig. 1) yield approximately 1,600 tons of guano a year. This represents about one third of the total annual guano yield for all the islands administered by the Union Government. The majority of the penguin eggs are collected from Dassen Island.

Although the price of guano increased from £11 per ton in 1953 to £13 per ton in 1956, the price still bears no relation to the real value of the guano. The sale price of this type of guano on the world market is over £50 per ton. The price of penguin eggs has remained at the figure of 7s. 6d. per dozen during the last four years. At this price the average annual takings on this luxury food line varied from over £3,800 to £4,633. However, the profit on penguin eggs seldom exceeds £1,500 in any one year.

In 1953 the total final sales figure for guano and penguin eggs was approximately £65,000. The cost of producing the guano and eggs, including the administration and maintenance of the islands, the collection of guano, etc. was £74,600. The total deficit for the year for guano and eggs was therefore £9,600 (Davies, 1955).

In 1954 the price realised for the 5,734 tons of guano produced was £67,375 and the figure for the 148,248 penguin eggs collected was £4,633. Thus, for the year's guano and penguin egg yield a total income of £72,008 was obtained. The cost of the production of the guano was £84,577, however, and of the collection and distribution of the penguin eggs £3,088. Thus, the sale of guano for the year showed a loss of £17,202 and *the sale*

of penguin eggs a profit of £1,545. The net loss on guano and eggs was therefore £15,657 for the year (Davies, 1956).

The position had not materially altered up to 1957 and guano is still sold at a considerable loss. The sale of penguin eggs continues to bring in a profit but in 1955 no collection was made and in 1956 fewer eggs were obtained.

If guano were sold on a realistic basis on the open market and not as a subsidised fertilizer the picture would be very different. For example, the 1954 guano production of 5,734 tons, sold on the overseas market, would have brought in an income of £286,700 in place of £67,375.

The situation in relation to the collection and sale of guano, which is produced as a result of the consumption by birds of large quantities of commercially-exploitable fish consumed in the area in which the commercial catching takes place and which could provide important additional protein-rich food for man and animals, is in direct conflict with the commercial pilchard/maasbanker fishery off the West coast of the Union.

Apart from the economically opposed nature of the situation where guano collection is made in the centre of the area of greatest activity of the commercial fisheries, it is in this case scientifically unsound actively to conserve large populations of sea-birds in order that they may consume large numbers of fish suitable for human consumption to produce guano which is then collected and sold to produce vegetables which are eaten by man. *The rational approach to the problem would be to control the numbers of birds thus decreasing their consumption of fish and making more available to the commercial fisheries for* direct *human consumption.*

Reduction of numbers could be effected by the carefully controlled breaking of the eggs of Cape cormorants and gannets at the beginning of the breeding season under the supervision of an experienced biologist. This form of control would merely be an extension of a method already in existence for the Cape penguin, viz. the annual collection of eggs.

The average annual catch of pilchards and maasbankers for the last six years is shown in the foregoing table and amounts to a combined total of 225,000 tons. The landed value at the present rates, which average £4 10s a ton, is over £1,000,000. The total value of this catch in terms of canned products, fish-meal and oil is over £5,000,000. On this basis the 50,000 tons of pilchards and maasbankers eaten each year by the birds off the West coast of the Union are worth £225,000 in terms of landed value and £1,125,000 in terms of final products.

Although the average catch of pilchards and maasbankers is 225,000 tons a year, it may fall as low as 134,000 tons. The total consumption of these two species by sea-birds is 50,000 tons a year at a very conservative estimate, a figure which represents 22 per cent of the average annual commercial catch. This figure may, however, increase to as much as 37 per cent of the annual commercial catch in bad years.

As a result of these investigations certain recommendations were made to the Secretary for Commerce and Industries concerning the present policy of the Department in relation to guano-producing birds

8. Acknowledgments.

I am indebted to Dr. J. M. Marchand, Director of Fisheries and Prof. J. H. Day of the University of Cape Town, and my former colleagues of the Division of Fisheries for reading and criticising this paper.

TABLE I.

AERIAL CENSUS OF GUANO BIRDS OFF THE WEST COAST OF THE UNION OF SOUTH AFRICA.
(made in November, 1956).

Island.	Gannet.	Cape Cormorant.	Penguin.
Lambert's Bay.....	6,200	31,000	±50
Malgas.....	24,300	—	1,060
Marcus.....	—	—	5,850
Jutten.....	—	28,350	9,450
Vondeling.....	—	800	375
Dassen.....	—	—	80,500
TOTAL.....	30,500	60,150	97,285

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